What is Claimed is:

1. A combinatorial optical processor, comprising one or more optical modules; wherein at least one of the one or more optical modules includes N addressable optical elements, where N is an integer greater than or equal to 1.

2. The combinatorial optical processor of claim 1 wherein the one or more optical modules including N addressable optical elements includes an optical medium having one or more subsections that define the one or more addressable optical elements; and means for altering the optical properties of the subsections.

3. The combinatorial optical processor of claim 2 wherein the means for altering the optical properties provide one or more optical address beams.

4. The combinatorial optical processor of claim 3 wherein optical medium is an electro-optic medium

5. The combinatorial optical processor of claim 4 wherein the means for altering the optical properties include one or more contact pads disposed proximate the optical medium and a voltage source coupled to one or more of the contact pads.

6. The combinatorial optical processor of claim 1 wherein the one or more optical modules including N addressable optical elements includes an optical medium having one or more subsections that define the one or more addressable optical elements.

7. The combinatorial optical processor of claim 6 wherein two or more of the optical modules are linked and oriented relative to each other such that optical transforms may be performed along two or more axes relative to an axis of propagation.

8. The combinatorial optical processor of claim 7 wherein the two or more modules comprise a first module and a second module wherein the first and second modules perform one-dimensional lens optical transforms and wherein the first and second modules are relatively oriented such that the two one-dimensional lens transforms are substantially perpendicular to each other whereby optical transforms in two dimensions can be achieved.

9. The combinatorial optical processor of claim 6 wherein the optical medium exhibits optical nonlinearities.

10. The combinatorial optical processor of claim 9 wherein the optical nonlinearities include second order nonlinearities.

11. The combinatorial optical processor of claim 9 wherein the optical nonlinearities include third order nonlinearities.

12. The combinatorial optical processor of claim 6 wherein the optical medium includes a material selected from the group of KH_2PO_4, KDP, or $LiNbO_3$.

13. The combinatorial optical processor of claim 6, further comprising one or more address beam sources, wherein each address beam source may produce an address beam that interacts with a corresponding subsection of the optical medium to alter one or more optical properties of the subsection.

14. The combinatorial optical processor of claim 6 wherein optical medium includes an electro-optic medium.

15. The combinatorial optical processor of claim 14 wherein the electro-optic medium includes a liquid crystal.

16. The combinatorial optical processor of claim 15 wherein the liquid crystal may have two or more states of refractive index as determined by an electric field applied across at least a portion of the electro-optic medium.

17. The combinatorial optical processor of claim 14, further comprising one or more contact pads disposed proximate the optical medium.

18. The combinatorial optical processor of claim17, further comprising a voltage source coupled to one or more of the contact pads.

19. The combinatorial optical processor of claim 17, further comprising one or more dispersed optics disposed proximate one or more of the contact pads.

20. The combinatorial optical processor of claim 19, wherein the dispersed optics include refractive, diffractive and binary optic lenses, micro-optic lenslets, bragg gratings, prisms, holographic optical elements, liquid crystals, ferroelectrics, semiconductors, electro-optics, polymers, thin films, glass or plastic.

21. The combinatorial optical processor of claim 17, further comprising one or more dispersed optics disposed within the electro-optic medium.

22. The combinatorial optical processor of claim 21, wherein the dispersed optics include refractive, diffractive and binary optic lenses, micro-optic lenslets, bragg gratings, prisms, holographic optical elements, liquid crystals, ferroelectrics, semiconductors, electro-optics, polymers, thin films, glass or plastic.

23. The combinatorial optical processor of claim 21, wherein the dispersed optics include one or more birefringent materials one or more optically isotropic materials.

24. The combinatorial optical processor of claim 23 wherein the dispersed optics are configured such that along a first polarization axis, the materials comprising the dispersed optics have a common refractive index and wherein along a second polarization axis, the materials comprising the dispersed optics have two or more refractive indices.

25. The combinatorial optical processor of claim 23 wherein the contact pads include one or more polarization rotators.

26. The combinatorial optical processor of claim 25 wherein the polarization rotators are selected from the group of dichroic films, liquid crystals, and electro-optic half-wave plates.

27. The combinatorial optical processor of claim 23 wherein the contact pads include one or more polarizers.

28. The combinatorial optical processor of claim 1 wherein the N addressable optical elements are configured such that, depending on a state of each addressable optical element, the combinatorial optical processor may provide at least 2^N addressable filter functions.

29. The combinatorial optical processor of claim 28 wherein each of the at least 2^N addressable filter functions produces a unique transform between an object and an image whereby there are at least 2^N transforms.

30. The combinatorial optical processor of claim 29 wherein the at least 2^N transforms form a set of related transforms.

31. The combinatorial optical processor of claim 30 wherein an n^{th} transform is related to an $(n+1)^{th}$ transform in the same way as an $(n-1)^{th}$ transform is related to the n^{th} transform, wherein n is an integer between 1 and N-1.

32. The combinatorial optical processor of claim 31 wherein, for an object at a given object location, each of the at least 2^N transforms images the object at a different addressable output plane location, whereby there are at least 2^N addressable output plane locations.

33. The combinatorial optical processor of claim 32 wherein each of the at least 2^N addressable output plane locations lies along the same optic axis as the input plane.

34. The combinatorial optical processor of claim 32 wherein the at least 2^N addressable output plane locations are uniformly spaced apart.

35. The combinatorial optical processor of claim 30 wherein each of the at least 2^N transforms images the object at a different addressable magnification, whereby there are at least 2^N addressable magnifications.

36. The combinatorial optical processor of claim 30 wherein each of the at least 2^N transforms images the object at a different addressable beam deflection angle, whereby there are at least 2^N addressable beam deflection angles.

37. The combinatorial optical processor of claim 29 wherein one or more of the addressable optical elements are selected from the group consisting of variable efficiency optics, holographic optical elements, and nonlinear optics, holographic optical elements imbedded in electrically-activated liquid crystals and electrooptic diffractive optical elements in domain patterned ferroelectric materials.

38. The combinatorial optical processor of claim 29 wherein the N addressable optical elements are randomly addressable.

39. The combinatorial optical processor of claim 38 wherein each addressable optical element is characterized by at least two states,

40. The combinatorial optical processor of claim 39 wherein each of the at least two states for a given addressable optical element is characterized by a different value for an optical property of the given addressable optical element.

41. The combinatorial optical processor of claim 40 wherein each addressable optical element is a holographic optical element

42. The combinatorial optical processor of claim 41 wherein the holographic optical element is a lens incorporated within a liquid crystal structure.

43. The combinatorial optical processor of claim 40 wherein the optical property is a focal length.

44. The combinatorial optical processor of claim 40 wherein between 2 and N randomly addressable optical elements are configured as a stack such that a total focal length of the stack f_{tot} may be approximated by:

$$f_{tot} = \left(\frac{1}{f_1} + \frac{1}{f_2} \dots \frac{1}{f_n} \right)^{-1},$$

wherein $f_1, f_2 \dots f_n$ are the focal lengths of the n addressable optical elements.

45. The combinatorial optical processor of claim 44 wherein the stack is a stack of thin lenses.

46. The combinatorial optical processor of claim 38 wherein the unique transform is selected from the group consisting of image distance transforms, object distance transforms, image magnification transforms, image plane curvature transforms, object plane curvature transforms, angular beam deflection transforms, spatial frequency transforms and beam spot size transforms.

47. The combinatorial optical processor of claim 38 wherein a state of each of the N addressable optical elements may be determined by a control signal.

48. The combinatorial optical processor of claim 47 wherein the control signal is chosen from the group consisting of electric, optical, thermal, mechanical, magnetic, acoustic and electromagnetic control signals.

49. The combinatorial optical processor of claim 47 wherein the control signal is a digital control signal.

50. The combinatorial optical processor of claim 49 wherein the digital control signal is an N-bit control signal.

51. The combinatorial optical processor of claim 50 wherein each bit of the digital control signal corresponds to a unique one of the N addressable optical elements, whereby a value of a given bit determines a state of a corresponding one of the N addressable optical elements.

52. The combinatorial optical processor of claim 49 wherein the combinatorial optical processor is configured to convert the digital control signal to one or more analog output optical signals.

53. The combinatorial optical processor of claim 47, further comprising a control conduit coupled to one or more of the addressable optical elements.

54. A combinatorial optical processor method, comprising the steps of:
receiving an optical signal from an object at a combinatorial optical processor having N randomly addressable optical elements, where in is an integer greater than or equal to 2;
selecting a state for each of the N randomly addressable optical elements in the combinatorial optical processor; and

producing an image of the object using the randomly addressable optical elements.

55. The method of claim 54 wherein there are at least 2^N possible combinations of states for the N randomly addressable optical elements.

56. The method of claim 54 wherein the producing step includes producing the image simultaneously at two or more output plane locations.

57. The method of claim 54 herein the selecting step includes providing a control signal to one or more of the N randomly addressable optical elements.

58. The method of claim 57 wherein the control signal is chosen from the group consisting of electric, optical, thermal, mechanical, magnetic, acoustic and electromagnetic control signals.

59. The method of claim 57 wherein the control signal is a digital control signal.

60. The method of claim 59 wherein the digital control signal is an N-bit control signal.

61. The method of claim 60 wherein each bit of the N-bit digital control signal corresponds to a unique one of the N addressable optical elements, whereby a value of a given bit determines a state of a corresponding one of the N addressable optical elements.

62. The method of claim 59, further comprising converting the digital control signal to one or more analog optical outputs using one or more of the N randomly addressable optical elements.

63. A method for optical digital to analog conversion comprising:
Receiving a digital control signal at a combinatorial optical processor having N randomly addressable optical modules; and
processing a radiative object using one or more of the N randomly addressable optical modules to produce a radiative image;
wherein each of the N randomly addressable optical modules may take on 2 or more different states, such that there are at least 2^N different possible transforms between the radiative object and the radiative image;
wherein the 2^N different possible transforms form an analog set.
wherein the digital control signal determines the state of each of the N randomly addressable optical modules.

64. The method of claim 63 wherein the analog set includes a sequence of transforms.

65. The method of claim 64 wherein the sequence of transforms is such that an n^{th} transform is related to an $(n+1)^{th}$ transform in the same way as an $(n-1)^{th}$ transform is related to the n^{th} transform, wherein n is an integer between 1 and N-1.

66. The method of claim 63 wherein the radiative object includes radiation in the form of acoustic, optical, or electromagnetic radiation.

67. The method of claim 63 herein the control signal is chosen from the group consisting of electric, optical, thermal, mechanical, magnetic, acoustic and electromagnetic control signals.

68. The method of claim 67 wherein the digital control signal is an N-bit control signal.

69. The method of claim 68 wherein each bit of the N-bit digital control signal corresponds to a unique one of the N addressable optical elements, whereby a value of a given bit determines a state of a corresponding one of the N addressable optical elements.

70. An imaging system, comprising:
one or more optical modules;
wherein at least one of the one or more optical modules includes N addressable optical elements, where N is an integer greater than or equal to 1.

71. The imaging system of claim 70 wherein the N addressable optical elements are configured such that, depending on the state of each addressable optical element, the optical module may provide at least 2^N addressable image transform functions.

72. The imaging system of claim 71 wherein the at least 2^N addressable image transform functions provide 2^N addressable output plane locations for a given input plane location.

73. The imaging system of claim 72 wherein each of the at least 2^N addressable output plane locations lies along the same optic axis as the input plane.

74. The imaging system of claim 73 wherein the at least 2^N addressable output plane locations are uniformly spaced apart.

75. The imaging system of claim 72 wherein one or more of the N addressable optical elements are configured to simultaneously produce an image at two or more of the addressable output plane locations.

76. The imaging system of claim 75 wherein one or more of the addressable optical elements are selected from the group consisting of variable efficiency optics, holographic optical elements, and nonlinear optics, holographic optical elements imbedded in electrically-activated liquid crystals and electrooptic diffractive optical elements in domain patterned ferroelectric materials.

77. The imaging system of claim 72 wherein the N addressable optical elements are configured such that, depending on the state of each addressable optical element, the imaging system may provide at least 2^N addressable magnification transforms for a given input plane location.

78. The imaging system of claim 72 wherein the N addressable optical elements are randomly addressable in response to a digital control signal.

79. The imaging system of claim 78 wherein the system is configured to convert the digital input control signal to one or more analog output optical signals.

80. The imaging system of claim 78 wherein the N addressable optical elements are configured to randomly address an image to one or more of the 2^N addressable output plane locations.

81. The imaging system of claim 78 wherein each addressable optical element is characterized by at least two states.

82. The imaging system of claim 81 wherein each of the at least two states for a given addressable optical element is characterized by a different value for an optical property of the given addressable optical element.

83. The imaging system of claim 82 wherein each addressable optical element is a holographic optical element

84. The imaging system of claim 83 wherein the holographic optical element is a lens incorporated within a liquid crystal structure.

85. The imaging system of claim 82 wherein the optical property is a focal length.

86. The imaging system of claim 82 wherein N is greater than or equal to 2 and the N randomly addressable optical elements are configured as a stack of thin lenses such that a total focal length F_1 for the at least one optical module may be approximated by:

$$F_1 = \left(\frac{1}{f_{1(0)}} + \ldots \frac{1}{f_{1(N-1)}} \right)^{-1},$$

wherein $f_1 \ldots f_n$ are the focal lengths of the N addressable optical elements.

87. The imaging system of claim 82 wherein, in a first state, each addressable optical element has an essentially infinite focal length.

88. The imaging system of claim 82 wherein in a second state each optical element has a finite focal length $f_{1(n)}$.

89. The imaging system of claim 88 wherein, for an n^{th} optical element, the focal length in the second state $f_{1(n)}$ is determined by:

$$f_{1(n)}=f_{1(0)}/2^n,$$

where n is an integer greater than or equal 0 and less than or equal to N-1, and $f_{1(0)}$ is a value of the focal length for the 0^{th} optical element when it is in the second state.

90. The imaging system of claim 70 where, in addition to the at least one optical module including N addressable optical elements, the system includes a second optical module optically coupled to the first optical module.

91. The imaging system of claim 90 wherein the second optical module includes a lens having a fixed focal length.

92. The imaging system of claim 90 wherein the second optical module includes M addressable optical elements, where M is an integer greater than or equal to 1.

93. The imaging system of claim 92 wherein the M addressable optical elements are configured such that, depending on the state of each addressable optical element, the imaging may provide at least 2^M addressable image transforms for a given input plane location.

94. The imaging system of claim 70 where, in addition to the at least one optical module including N addressable optical elements, the system includes a two or more optical modules optically coupled to the first optical module.

95. A three-dimensional display apparatus, comprising:
a first optical module;
a second optical module optically coupled to the first optical module;
an object source optically coupled to the first module; and
a module controller coupled to one or more of the first and second optical modules,
wherein at least one of the first and second optical modules includes N addressable optical elements, where N is an integer greater than or equal to 1,
wherein the first and second modules may be synchronized with the object source, thereby translating information from the object source onto one or more image plane locations to produce a three-dimensional image.

96. The apparatus of claim 95 wherein object source information is generated at a frequency that is sufficiently rapid for the unaided human perception of simultaneous images.

97. The apparatus of claim 95 wherein the module controller controls one or more of the first and second modules at a frequency that is sufficiently rapid for the unaided human perception of simultaneous images.

98. The apparatus of claim 95, further comprising a system controller coupled to one or more of the object source and module controller.

99. The apparatus of claim 95, further comprising a means for disposing an imaging medium proximate one or more of the image plane locations.

100. The apparatus of claim 99 wherein the imaging medium is chosen from the group of microscopic glass beads, liquid vapor, and ionized gases and fluorescing gases

101. The apparatus of claim 99 wherein the means for disposing an imaging medium includes an imaging chamber disposed proximate one or more of the image plane locations.

102. The apparatus of claim 95, further comprising an imaging chamber configured to dispose an imaging medium proximate one or more of the image plane locations.

103. The apparatus of claim 102 wherein the imaging medium is chosen from the group of microscopic glass beads, liquid vapor, and ionized gases and fluorescing gases.

104. The apparatus of claim 95 wherein the three-dimensional image is a real image existing in free space.

105. The apparatus of claim 104, further comprising a partial reflector optically coupled between the object source and the three-dimensional image.

106. The apparatus of claim 105, further comprising a detector coupled to the module controller.

107. The apparatus of claim 106 wherein the detector is optically coupled to the partial reflector such that light from one or more of the image plane locations may then be reflected from a pointer and transmitted through the first and second modules and coupled to the detector via the partial reflector.

108. The apparatus of claim 107 wherein the detector is coupled to the object source.

109. The apparatus of claim 108 wherein the presence and location of the pointer may be identified and utilized to interact with the generation of the three-dimensional image.

110. The apparatus of claim 109 wherein an interaction between the pointer and the three-dimensional image enables an observer to perceive virtual contact with an object generated by the object source.

111 The apparatus of claim 110 wherein the interaction between the pointer and the three-dimensional image includes a physical feedback means.

112. The apparatus of claim 110 wherein the pointer is configured to provide the observer with physical feedback related to three-dimensional image.

113. The apparatus of claim 105 wherein the partial reflector is chosen from the group consisting of partially reflective mirrors, polarizers and optical gratings.

114. A linked combinatorial optics system, comprising:

a first combinatorial optics system; and

a second combinatorial optics system optically coupled to the first combinatorial optics system,

wherein each of the first and second combinatorial optics systems includes one or more optical modules; wherein at least one of the one or more optical modules includes N addressable optical elements, where N is an integer greater than or equal to 1.

115. The system of claim 114 wherein the first system is configured to optically process an object to produce a three-dimensional intermediate image.

116. The system of claim 115 wherein the object is a two-dimensional object.

117. The system of claim 115 wherein the object is an array of data.

118. The system of claim 115 wherein the second system is configured to optically process the intermediate image to produce an image.

119. The system of claim 118 wherein the image is a three dimensional image.

120. The system of claim 114 wherein the first system is configured to optically process an object to produce a two-dimensional intermediate image.

121. The system of claim 120 wherein the object is a three-dimensional object.

122. The system of claim 120 wherein the second system is configured to optically process the intermediate image to produce an image.

123. The system of claim 124 wherein the image is a two dimensional image.

124. The system of claim 114 wherein the N addressable optical elements are configured such that, depending on a state of each addressable optical element, the linked combinatorial optical system may provide at least 2^N addressable filter functions.

125. The system of claim 126 wherein each of the at least 2^N addressable filter functions produces a unique transform between an object and an image whereby there are at least 2^N transforms.

126. The system of claim 127 wherein the at least 2^N transforms form a set of related transforms.

127. The system of claim 128 wherein an n^{th} transform is related to an $(n+1)^{th}$ transform in the same way as an $(n-1)^{th}$ transform is related to the n^{th} transform, wherein n is an integer between 1 and N-1.

128. The system of claim 127 wherein, for an object at a given object location, each of the at least 2^N transforms images the object at a different addressable output plane location, whereby there are at least 2^N addressable output plane locations.

129. A compound linked combinatorial optics system, comprising:

a first combinatorial optics linked system; and

a second combinatorial optics linked system optically coupled to the first combinatorial optics system,

wherein each of the first and second combinatorial optics linked systems includes

a first combinatorial optics system; and

a second combinatorial optics system optically coupled to the first combinatorial optics system,

wherein each of the first and second combinatorial optics systems includes one or more optical modules; wherein at least one of the one or more optical modules includes N addressable optical elements, where N is an integer greater than or equal to 1.

130. The system of claim 129 wherein the first linked system is characterized by a first optic axis and the second linked system is characterized by a first optic axis that is substantially orthogonal to the first optic axis.

131. The system of claim 129 wherein the first linked system is configured to optically process an object to produce a first intermediate image.

132. The system of claim 131 wherein the object is a two-dimensional object.

133. The system of claim 131 wherein the object is three-dimensional.

134. The system of claim 131 wherein the second linked system is configured to optically process the first intermediate image to produce a second intermediate image.

135. The system of claim 134 wherein the second intermediate image is a three dimensional image.

136. The system of claim 134 Further comprising a third combinatorial optics linked system having first and second combinatorial optics systems, wherein each of the first and second combinatorial optics systems includes one or more optical modules; wherein at least one of the one or more optical modules includes a first optical module, the first optical module having N addressable optical elements, where N is an integer greater than or equal to 1.

137. The system of claim 136 wherein the third combinatorial optics linked system is configured to optically process the second intermediate image to produce an image.

138. The system of claim 136 wherein the first linked system is characterized by a first optic axis and the second linked system is characterized by a first optic axis that is substantially orthogonal to the first optic axis.

139. The system of claim 138 wherein the third linked system is characterized by a third optic axis that is substantially orthogonal to one or more of the first and second optic axes.

140. The system of claim 139 wherein the first, second and third optic axes are mutually orthogonal to each other.

141. The system of claim 130 wherein the N addressable optical elements are configured such that, depending on a state of each addressable optical element, the first or second linked combinatorial optics system may provide at least 2^N addressable filter functions.

142. The system of claim 141 wherein each of the at least 2^N addressable filter functions produces a unique transform between an object and an image whereby there are at least 2^N transforms.

143. The system of claim 142 wherein the at least 2^N transforms form a set of related transforms.

144. The system of claim 143 wherein an n^{th} transform is related to an $(n+1)^{th}$ transform in the same way as an $(n-1)^{th}$ transform is related to the n^{th} transform, wherein n is an integer between 1 and N-1.

145. The system of claim 144 wherein, for an object at a given object location, each of the at least 2^N transforms images the object at a different addressable output plane location, whereby there are at least 2^N addressable output plane locations.

146. A combinatorial optical processor, comprising:

means for receiving an optical signal from an object at a combinatorial optical processor having N randomly addressable optical elements, where in is an integer greater than or equal to 2;

means for selecting a state for each of the N randomly addressable optical elements in the combinatorial optical processor; and

means for producing an image of the object using the randomly addressable optical elements.

147. A combinatorial optical processor, comprising one or more optical modules; wherein at least one of the one or more optical modules includes N randomly addressable optical elements, where N is an integer greater than or equal to 1,

wherein the N randomly addressable optical elements are configured such that, depending on a state of each randomly addressable optical element, the combinatorial optical processor may provide at least 2^N randomly addressable filter functions, wherein each of the at least 2^N randomly addressable filter functions produces a unique transform between an object and an image whereby there are at least 2^N transforms,

wherein the at least 2^N transforms form a set of related transforms,

wherein an n^{th} transform is related to an $(n+1)^{th}$ transform in the same way as an $(n-1)^{th}$ transform is related to the n^{th} transform, wherein n is an integer between 1 and N-1,

wherein one or more of the optical modules includes a nonlinear optical medium having one or more subsections that define one or more of the N addressable optical elements.